
Space Weather Technical Forecast

Issued on Monday, 27 November 2023 at 13:18 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: Chance of isolated M-class flares. Chance of G1-G2 Minor/Moderate storms with CME arrival late day 3/early day 4 (29-30 Nov)

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low, with a peak C3.4 flare at 27/0811 UTC from AR3490 in the northwest disc. There are eleven sunspot regions on the visible disc. AR3490 is the lead and also a decaying member of the group of three regions in the northwest disc. These regions are looking increasingly simple with AR3490 and AR3492 both unipolar, while AR3502 is bipolar but also smaller. The largest region on the disc is AR3500 in the southeast, consisting of a compact collection of umbrae. The trailer shares some penumbra with an opposite polarity region, resulting in a delta-configuration, however the spot is magnetically relatively simple, with a simple bipolar configuration and little shear or twisting evident across its parity separation line. All other regions persist as either smaller or mature sunspot groups.

There are a number of filaments on the Earth-facing disc, with a broad eruption around 27/0535 UTC alongside a C3.3 flare. This produced a CME which is still under analysis, however a preliminary assessment suggests an Earth-directed component with arrival either late day 3 or early day 4 (29-30 Nov).

Solar Wind / Geomagnetic Activity: Weak coronal hole influence, from CH75/+, receded through the period. Solar wind speeds declined from elevated to be slightly elevated, 550 km/s to 450km/s. Density declined from being at or above average to be below average. Interplanetary Magnetic Field (IMF), Bt, was weak 4-6nT, with north-south component, Bz weak and variable between +5 nT and -4 nT. Phi angle was positive (away from the Sun). Geomagnetic activity was Quiet (Kp 0-2).

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux remained at Background. GOES16 high energy (greater than 2MeV) electron flux has been at Background. The associated 24-hour fluence has remained below the Active threshold (1e8 integrated pfu). The observation at 27/0000 UTC was 1.55e6 integrated pfu.

Four-Day Space Weather Forecast Summary

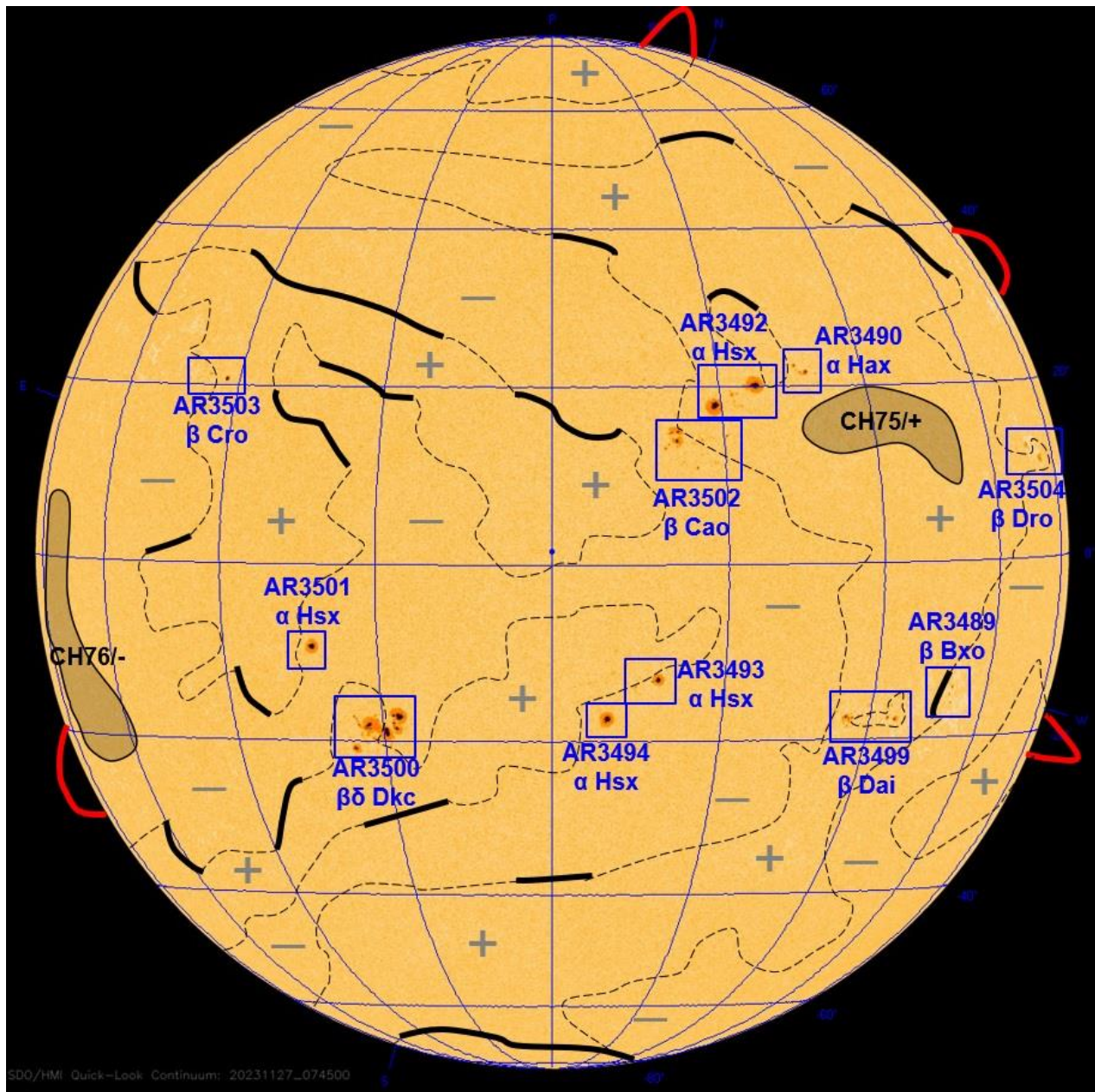
Solar Activity: Solar activity is expected to be Low to Moderate, with a chance of isolated M-flares. These most likely if any further development occurs, especially with AR3500.

Solar Wind / Geomagnetic Activity: There are potentially two Earth-directed CMEs. The first is low confidence, from 24 Nov, perhaps giving a slight glancing impact later on day 1 (27 Nov). The second is still under analysis, originating from the broad filament eruption off the southwest disc earlier on 27 Nov. A preliminary assessment suggests arrival late on day 3 or early day 4 (29-30 Nov). Otherwise current fast wind conditions are expected to gradual ease with no other enhancements indicated. Quiet geomagnetic activity is expected, with isolated Unsettled spells day 1-2 (27-28 Nov). Active to G1 Minor Storms intervals possible from any CME glance day 1 (27 Nov). Active to G1 Minor Storms are likely, with a slight chance for G2 Moderate storm intervals from any impact from the second CME, late day 3 or early day 4 (29-30 Nov). Activity easing later day 4 (30 Nov).

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Energetic Particles / Solar Radiation: GOES16 high energy proton flux is expected to remain at Background levels. There is a slight chance of flux towards or perhaps exceeding the S1 level given any significant flares from the active regions on the disc, or from any notable filament eruptions. Electron flux is currently at background, but with a chance of rising to Moderate, perhaps reaching High at diurnal maximum days 2-3 (28-29 Nov). The associated fluence is expected to increase in response, but likely staying below the Active (1e8 integrated pfu) threshold. Any CME arrival later day 3 or early day 4 (29-30 Nov) will further limit this potential, leading to a drop out in flux when it occurs.

Figure 1. Solar Analysis Valid 27/0800 UTC.



Key: Filament —, Prominence —, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-γ-δ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

There are potentially two Earth-directed CMEs. The first is low confidence, originating from a C-flare of AR3499 on 24 Nov, with the potential to give a slight glancing impact later on day 1 (27 Nov). The second is still under analysis and originated from the broad filament eruption off the southwest disc around 27/0535 UTC. A preliminary assessment suggests arrival late on day 3 or early day 4 (29-30 Nov).

Current slightly elevated solar winds are due to a waning connection to CH75/+. These wind are expected to continue easing during the next 24-48 hours, in agreement with MOSWOC enlil. There are no other notable enhancements indicated during this period.

Quiet geomagnetic activity is expected, with isolated Unsettled spells day 1-2 (27-28 Nov). Any glance from the first CME could bring a spell of Active, with a slight chance G1 Minor Storms. The second filament eruption CME is currently expected to arrive later day 3 or early day 4 (29-30 Nov), bringing a spell of Active to G1 Minor Storms, and a slight chance of G2 Moderate storm intervals. This activity easing later day 4 (30 Nov).

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	10	1	20	40
Strong	G3	No	1	1	5	5
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed (km/s)	Estimated Arrival Time	Comments
24/1707	Nil	AR3499 C-flare	SW	572	Glancing 27 Nov	Limited shock, very low confidence.
27/1135	Partial	Filament	SW	717	27/2300 UTC	Preliminary assessment. Changes likely to forecast.

Figure 2a Enlil and Ensemble: Weak glancing impact of 24 Nov CME shown (expected later and weaker than indicated), along with preliminary assessment of 27 Nov CME

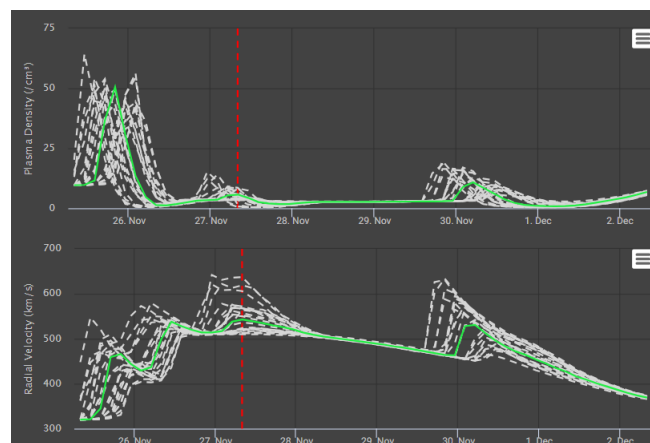
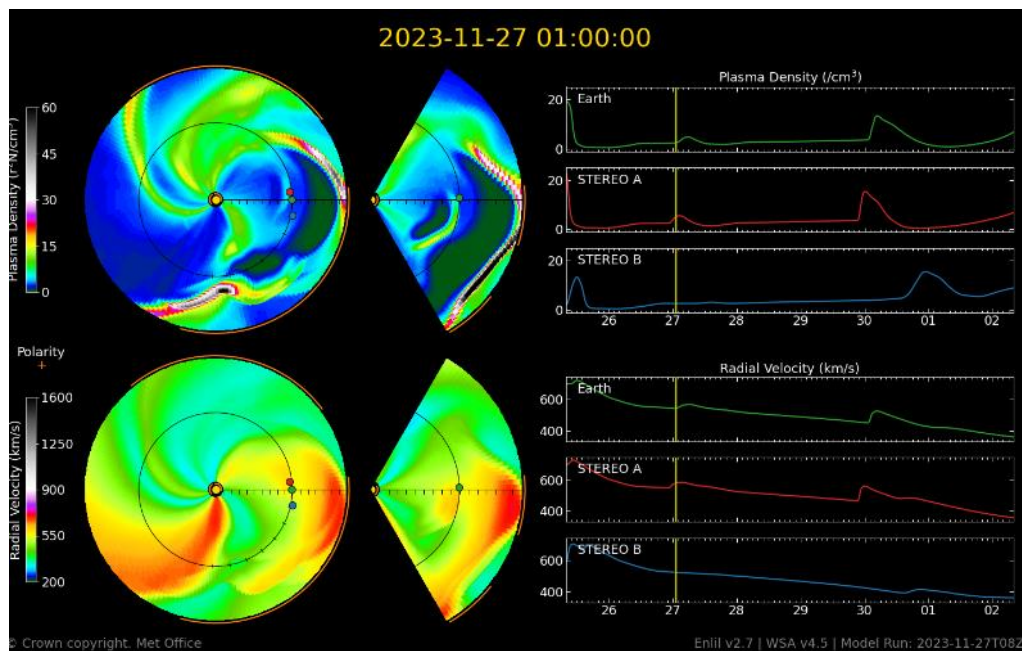
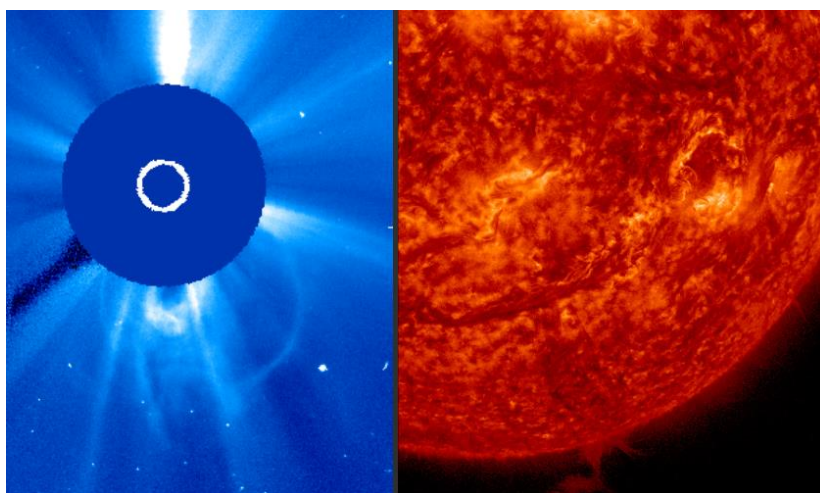


Figure 2b SOHO C3 (left) and SDO aia-304 (right) showing filament eruption and resultant CME:



Radio Blackouts - X-Ray Flares:

Low to Moderate activity is forecast. There are eleven sunspots regions, the majority of which are stable and mature features with little flare activity, however there are a few regions of note.

AR3500 is the largest region on the disc, as a moderately sized sunspot in the southeast considering of a collection of small dark umbrae cores in relatively close proximity. Despite its compact size, the negative trailer remains separate from the leader, with only a weak delta spot evident. Consequently, the lack to twisting or shear across the parity separation line has led to this region remaining stable.

The collection of three sunspots in the northwest disc continues to weaken. These spots are AR3490, now a small unipolar spot, AR3492, consisting of two larger but same polarity and mature spots, and AR3502 which is bipolar but smaller than the other two. AR3499 is perhaps the next most notable region, in the southwest, but this also has a simple bipolar configuration. AR3504, nearing the northwest limb, while small, was the only region where any notable growth observed.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	45	45	45	45
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3a: GOES-16/18 X-ray Flux

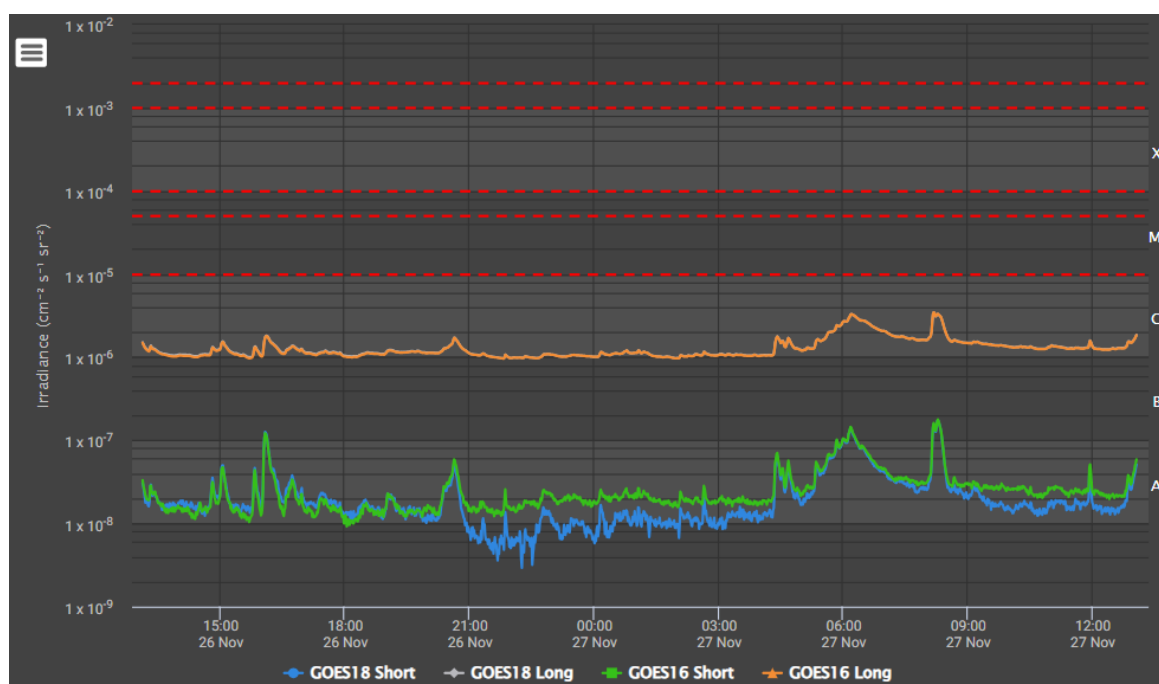
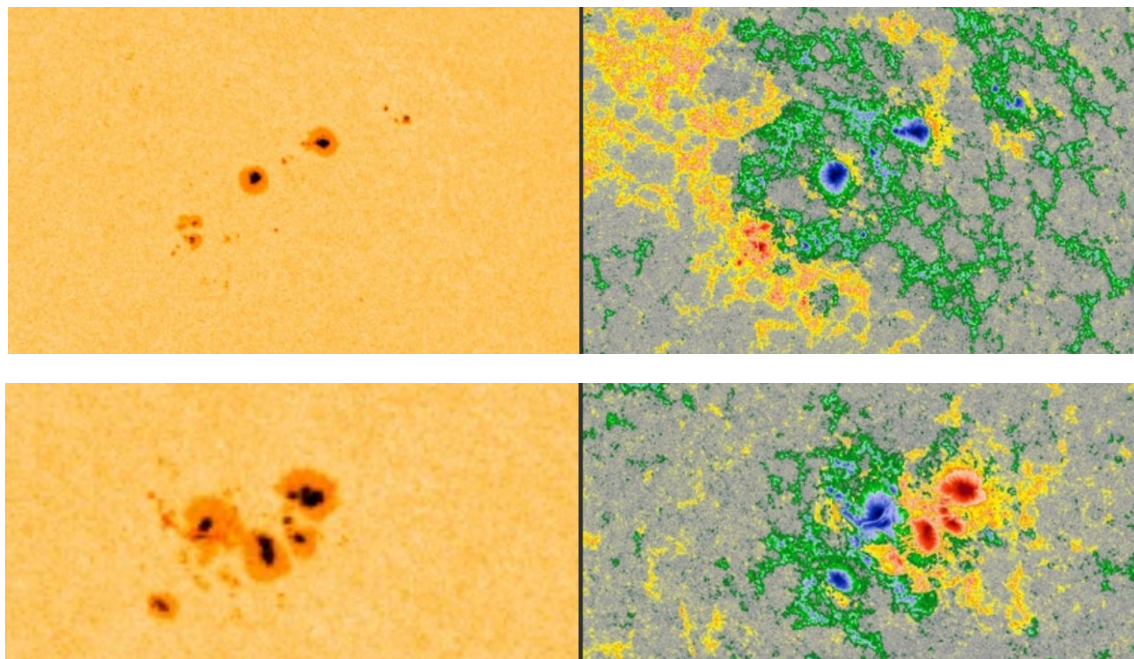


Figure 3b: SDO intensitygram (left) and magnetogram (right) of AR3490/3492/AR3502 (top) and AR3500 (bottom) (zoom levels slightly different on each)



Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is currently at Background. There are number of moderately sized sunspot regions on the disc, however the majority of these are magnetically simple mature spots with no significant activity. The main exception is currently AR3500 in the south-east, which is both the largest region and maintains a weak beta-delta configuration. There are also a number of filaments on the Earth-facing disc, and large eruptions, especially off the west disc, can result in proton flux increasing at Earth, albeit likely staying below the S1 Minor Radiation Storm level.

Overall this gives a slight chance of elevated protons through the period, with this risk increasing a little as AR3500 moves into the western disc.

Radiation Storms	Level (cm ⁻² sr ⁻¹ s ⁻¹)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	No	5	10	10	10
Very Active	≥ S3 *	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = cm⁻²sr⁻¹s⁻¹)

High Energy Electrons Event ($\geq 2\text{MeV}$):

High energy electron flux observed by GOES-16 is currently at background, having been suppressed by recent elevated solar wind pressure due to the recent CME and CH HSS arrival. The influence of these has now, or is currently receding. This is likely to be followed by an increase in electron flux at GEO, likely to Moderate levels with diurnal peaks of high. There is a slight chance of this becoming predominately High day 3 (29 Nov), however the arrival of any further CME is likely to bring a drop out in flux later day 3 and into day 4 (29-30 Nov).

Overall, the electron fluence is expected to remain below Active ($1\text{e}8$ integrated pfu), although there is a slight chance of rising towards this level later on day 3 (29 Nov) before the arrival of any CME. REFM is currently over-estimating current fluence, but gives support to below Active fluence persisting.

GEO Electron Environment	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^8$	No	1	10	15	15
Very Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^9$	No	1	1	1	1

Figure 4: GOES-16 Electron Flux and Fluence with REFM

